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ABSTRACT

An earlier study indicated that a subject's performance on simple mental tasks, such as tracing soluble and unsoluble geometric designs and proofreading, was not affected by background noise regardless of its intensity, unpredictability, or uncontrollability. But, since background noise did have a significant effect on postnoise task performance, it was concluded that the perception of having no control debilitated the quality of postnoise performance. Later studies indicated that the intensity of the noise can influence task performance, whether it is presented prior to or during the task. The main concern of this experiment was to determine whether cognitive factors would be more influential than the intensity variable in a reaction time experiment. It was found that at 105 decibel noise levels, intensity was the crucial variable, whereas at 70 decibel levels the predictability of the background noise was of primary importance. (BW)

WHY DOES BACKGROUND NOISE DEBILITATE SIMPLE TASK PERFORMANCE?

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Abstract

Glass and Singer (1972) have proposed that the *cognitive* effects of background noise, e.g., its unpredictability, are more important than *intensity* effects in reducing performance efficiency. The present study permits a comparison of the effects of noise intensity (in dB) and mode of presentation (unpredictable, predictable, and self-administered) on simple RT to auditory and visual test signals. It was found that at 105-dB noise levels, intensity was the crucial variable, whereas at 70-dB levels the predictability of the background noise was of primary importance.

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A major impetus for the present research was provided by the work of Glass and Singer (1972) in which both the cognitive aspects and the physical intensity of background noise were evaluated. The cognitive aspects of noise were defined as its predictability or controllability by the subject. Specifically, predictable noise was either signalled or was presented at regular intervals throughout the experimental session, whereas unpredictable noise was presented randomly and intermittently so that the onset, duration, and termination of the noise was unpredictable. Uncontrollable noise was administered by depriving the subject of any means for terminating, avoiding, or escaping the noise stimulation, whereas in controllable noise situations, the subject had the option of terminating the noise at any time during the experiment.

Two of the tasks employed by Glass and Singer were described as simple mental tasks. One task required the tracing of soluble and unsoluble geometric designs as a measure of tolerance for frustration, and the other was a proofreading task which was used to assess accuracy of performance. It was found that noise, regardless of its intensity, unpredictability, or uncontrollability had little effect on simple task performance when the tasks were performed during the noise exposure. However, background noise did have a significant effect on postnoise task performance. The Ss who were preexposed to 108-dB (strong) unpredictable noise were the least persistent in their attempts to trace unsoluble puzzles, and by interpretation, showed the lowest tolerance for performing a frustrating task. Moreover, the Ss who were preexposed to 56-dB (weak) unpredictable noise also showed significantly lower tolerance for frustration than Ss in either the Strong-Intensity or Weak-Intensity Predictable Noise conditions. It is noteworthy that

Ss preexposed to the strong- and weak-intensity predictable noise did not differ significantly from either each other or the No-Noise Control group in terms of postnoise frustration tolerance. These findings would seem to indicate that the cognitive aspects of background noise, e.g., its predictability or unpredictability, are more influential in producing deleterious aftereffects than is the physical intensity of the noise.

But why does unpredictable background noise debilitate postnoise task performance? In a subsequent study, Glass and Singer (1972) varied the amount of control given the S over the noise to which he was exposed. Two groups of Ss were exposed to strong-intensity unpredictable noise. One group, the Perceived-Control group, was given a button to press which they were told would terminate the noise for the rest of the session, whereas the No-Perceived-Control group was not given a chan to terminate the background noise. Despite the fact that very few Ss in the Perceived-Control-group actually switched off the noise, the Ss in this group who chose not to terminate the noise had a much higher tolerance for frustration and a much lower number of errors in a proofreading task than Ss in the No-Perceived-Control group. Furthermore, it was found that the Ss who were given the perception of control over the unpredictable background noise performed equally well on postnoise tasks as the Ss who received predictable noise, or no noise at all.

On the basis of this research, Glass and Singer concluded that the perception of having no control, and the concomitant stress of this perception, is the reason why unpredictable background noise debilitates the quality of postnoise performance on relatively simple tasks.

There is, however, some alternative evidence which indicates that the intensity of background noise is indeed a potent factor in simple task performance. Specifically, a series of simple reaction time (RT) studies in our laboratories (Murray & Kohfeld, 1965; Kohfeld, 1968; 1969a; 1969b) has shown that when Ss were exposed to intense stimulation prior to the presentation of a response signal, RT was considerably worse than when Ss were preexposed to moderate or weak stimulation. One of our studies (Kohfeld, 1968) seems particularly analogous in design to the postnoise experiments reported by Glass and Singer. In our experiment, Ss were seated in a sound-treated room and asked to listen to 12 brief (1.5 sec.) presentations of a stimulus over a period of four min. Separate groups were preexposed either to 35-dB, 65-dB, or 100-dB (SPL) tones. Three additional groups of Ss were given corresponding intensities of white noise in the same manner. A warning light was presented just prior to the onset of a noise or tone in order to increase the predictability of the preexposure stimulus. Immediately following these procedures, a conventional RT task was administered. The results indicated that mean RT was fastest for the groups preexposed to the 35-dB signals, slowest for the groups preexposed to 100 dB, and intermediate for the Ss exposed to the 65-dB stimuli. If one refers to these data in terms of progressive decrements in RT performance, it can be argued that prior exposure to intense noise or tones debilitated simple task performance in comparison with preexposure either to moderate or weak stimulation. It is important to note that subsequent research in our laboratory (Kohfeld, 1969a; 1969b) has shown that the background stimuli which influence task performance do not have to be presented prior to the task itself, but can be spaced and distributed throughout the actual performance of

the task.

The experiment that is reported here represents a test of the alternative views we have introduced concerning the effects of noise on simple task performance. Our experimental procedure differed from those reported by Glass and Singer in that we employed a simple RT paradigm and presented the background noise during the intertrial interval of the RT task. Thus, our main concern was not necessarily to refute their conclusions, but rather to determine whether cognitive factors would be more influential in the RT situation than the intensity variables which we considered to be important.

METHOD

Table 1 represents a summary of the design employed in our experiment. Most of the information presented in Table 1 is self-explanatory.

Insert Table 1 about here

In terms of the alternative hypotheses under consideration; if a strict interpretation of Glass and Singer's hypothesis is correct, a main effect due to Variable A should result (RT would be the slowest in the Unpredictable Noise conditions), whereas the effect of Variable B should be insignificant. On the other hand, if a strict Intensity Hypothesis was to hold, Variable B should produce a main effect (RT would be slowest in the 105-dB Noise condition), and Variable A should have no main effect. Actually, we were open to the potential significance of both the major variables, as well as to a possible A X B interaction.

It should also be mentioned that previous RT research (e.g., Kohfeld, 1971) has shown that equal intensities of light and sound produce equal RTs when the visual signals are above the photopic threshold (circa

47 dB of light and sound). Accordingly, we predicted no main effect for Variable C, White light vs. White noise. Finally, Variable D, Stimulus Intensity, would obviously be highly significant.

As mentioned previously, the background noise was presented during the 16-sec. intertrial interval (ITI) of the RT task. Table 2 portrays the temporal distribution of the noise bursts utilized in the Unpredictable Background Noise conditions. The 16 sec. listed horizontally on

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Insert Table 2 about here

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the top of the table represents the ITI. The seven different combinations of background noise are listed in the left panel. In the body of Table 2, one single dot represents one, 1-sec. burst of noise; two dots joined by a solid line represents one, 2-sec. burst; and three dots joined by a solid line represents one, 3-sec. noise burst. The order of the seven possible presentations of background noise was randomized throughout the ITIs in each RT session. It may also be seen that there was a 3-sec. buffer time from response-signal offset to the first second in which it was possible to get a noise burst. There was a 4-sec. buffer time between the last second it was possible to get a noise burst and the onset of the RT ready signal.

The predictable background noise consisted of one, 2-sec. burst like that depicted in Table 2. A 10-watt warning light was flashed two seconds prior to the onset of the predictable noise burst. In the Self-Administered Background Noise condition the S had a foot switch to depress which initiated the onset of the one, 2-sec. noise burst. The foot switch had to be depressed before the 12th second of each 16-sec. ITI, or the one, 2-sec. noise burst was presented automatically.

Thus, it was possible for the subject to control the time of onset of the 2-sec. noise burst, even though it was not possible to avoid the noise.

A tactual ready signal was employed. Foreperiod intervals of 1, 2, or 3 seconds were given in random order on successive trials. The response consisted of tapping a telegraph key to the onset of the RT signals.

RESULTS

It should first be mentioned that the results of the 4-way analysis of variance depicted in Table 1 revealed no significant differences in mean RT to comparable levels of light and noise signals (Variable C). Furthermore, Light vs. Noise did not interact significantly with the other three major variables in the analysis. Accordingly, the data were collapsed over modalities for easier graphic presentation.

The left panel of Fig. 1 shows RT as a function of the three response-signal intensities for the 105- and 70-dB Unpredictable Background Noise (UPBN) conditions, and the No-Noise Control condition.

Insert Figure 1 about here

The center panel and right panel of Fig. 1 depict similar plots of the Predictable Background Noise (PBN) and the Self-Administered Background Noise (SABN) conditions, respectively. The left panel of Fig. 1 indicates that the 0-dB Control condition produced much shorter RTs than either the 105-dB or the 70-dB UPBN conditions. The apparent difference between the RT functions of the latter two conditions was not statistically significant, $\underline{t}$ (30) = .91. The center panel of Fig. 1 shows that the 105-dB PBN group produced much slower RTs than either the 70-dB PBN

condition or the 0-dB Control condition, the data for the latter two conditions being almost identical. Finally, the right panel of Fig. 1 reveals that the three SABN conditions were similar to their corresponding PBN conditions, a conclusion confirmed by a series of simple test comparisons.

In regard to the major hypotheses outlined previously, a main effect of Variable A (Type of Background Noise) was not obtained, F (2, 135) = 1.61, ns., whereas the effect of Variable B was highly significant, F (2, 135) = 9.31, $p < .001$. The main effect of Variable D was, as usual, very large, F (2, 270) = 590. Since the A X B interaction approached, but did not reach statistical significance in the 4-way ANOVA design, F (4, 135) = 2.03, $.05 < p < .10$, one might be tempted to accept the Intensity Hypothesis, and thus argue that the intensity factor is more important than the predictability (cognitive) factor in the RT paradigm. However, a careful comparison of the 70-dB Background Noise conditions across the three panels of Fig. 1 suggests an important exception to a strict interpretation of the Intensity Hypothesis. Clearly, the 70-dB UPBN condition produced slower RTs than both the 70-dB PBN and the 70-dB SABN conditions, and observation confirmed by a simple test comparison, F (2, 45) = 8.90, $p < .001$.

Another group of simple tests in the SABN condition deserves mention. As you may recall, the Ss in the two SABN conditions had the option of choosing when, during the ITI, they "wished" to listen to the background noise. Given this option, the time between the presentation of the background noise and the presentation of the response signal could vary between 4.5 sec. to 17.5 sec. depending upon whether the S was a "late-pusher" (one who waited at least 6 seconds before initiating the noise burst), or an "early pusher" (one who initiated the noise burst 4 sec. or less after the start of the ITI). Simple

tests comparing the performance of early pushers with that of late pushers for both the 105-dB and 70-dB SABN conditions revealed non-significant results, $\underline{t}$ (10) = .33, and $\underline{t}$ (11) = -.78, respectively. These tests indicate that differences in the time between presentation of the self-administered background noise and presentation of the response signal did not influence subsequent RT performance.

DISCUSSION

We now return to our original question...why does background noise debilitate simple task performance? We think that if the noise is loud enough, the question reduces to an analysis of how intensity variables interfere with continued performance. At intermediate levels of background noise, cognitive variables seemingly play an important role. That is, if the noise is unpredictable, performance is just as poor as when the noise is very intense; whereas, if the noise is predictable, whether signalled or self-administered, performance is equally good as in No-Noise conditions. A possible practical implication of these considerations is that somewhere between 70 dB and 105 dB, a background noise level exists at which no degree of cognitive control will change its debilitating effects on simple task performance, whereas another level exists at which predictability and/or controllability is beneficial to the individual.

We would like to comment on the relationship of our findings to those of Glass and Singer (1972). When simple task performance involves the rapid detection of sensory information, as in the present study, we suggest that either the physical intensity or the cognitive aspects of background noise might be involved, depending on the sheer intensity of the noise itself. However, if a task does <u>not</u> require rapid signal

detection, or possibly speedy information processing (e.g., problem solving tasks such as those employed in Glass and Singer's research), we agree that the cognitive aspects of background noise are likely to predominate.

Another conclusion which is warranted by our data is that the effect of background noise is not restricted to the processing of auditory information in a simple RT task. You may recall that not only was there no significant difference in mean RT to light and noise, but also that the effects of each of the seven background noise conditions were relatively equal for the visual and auditory RT signals. This finding indicates that the effects of background noise are not restricted to peripheral mechanisms, but reflect processes which are more central in nature. In fact, it is reasonable to predict that if the present study was replicated using background "light", similar results should be obtained. These interpretations are consistent with the data obtained by Kohfeld (1969b) in which equally intense auditory and visual ready signals produced identical results in a RT test to auditory signals.

As far as the "central" mechanisms which underly the presently obtained effects are concerned, we are hypothesizing that intense noise interferes with the attentional precision which is necessary to optimize rapid detection of signals in a given channel, thus slowing the initiation of a response. When background noise is moderate, but unpredictable, the individual also adopts an elevated detection criterion because the extraneous, albeit irrelevant stimulation debilitates, in a general manner, a person's capacity to pay close attention to forthcoming signals. In this vein, we propose that detection processes are a subset of the variables which are influenced by a more general attention-control system. While these observations are obviously

speculative, their implications are being tested in further research, and are being analyzed more precisely according to a combined attention-switching and detection-theory model, the results of which will be presented in another place.

In the meantime, if we were pressed to answer directly the question posed in the title of this paper, we would reply that background noise debilitates simple task performance because it is either too loud, or if it is not too loud, then because it is unpredictable.

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TABLE AND FIGURE CAPTIONS

Table 1. Experimental design.

Table 2. Temporal distribution of the noise bursts of the seven combinations of unpredictable noise.

Figure 1. Mean RT as a function of stimulus intensities collapsed across white light and white noise response signals for each of the three cognitive modes of background noise presentation.

RESPONSE SIGNALS

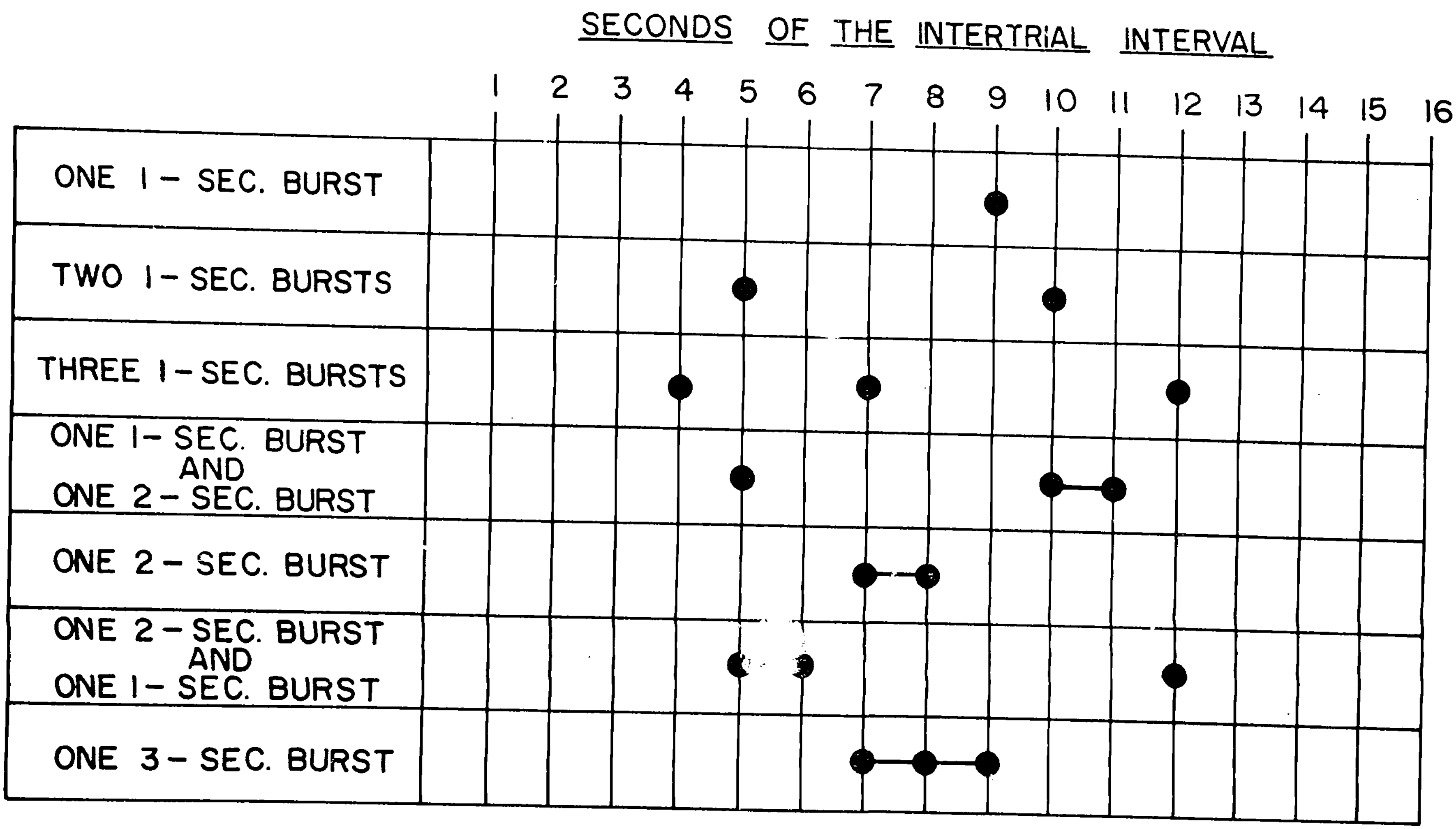
		LIGHT (C_1)			NOISE (C_2)		
		60 dB (D1)	70 dB (D2)	80 dB (D3)	60 dB (D1)	70 dB (D2)	80 dB (D3)
UNPREDICTABLE BACKGROUND NOISE (A1)	105 dB (B1) N=16						
	70 dB (B2) N=16						
	0 dB (B3) N=16						
PREDICTABLE BACKGROUND NOISE (A2)	105 dB (B1) N=16						
	70 dB (B2) N=16						
	0 dB (B3) N=16						
SELF - ADMINISTERED BACKGROUND NOISE (A3)	105 dB (B1) N=16						
	70 dB (B2) N=16						
	0 dB (B3) N=16						

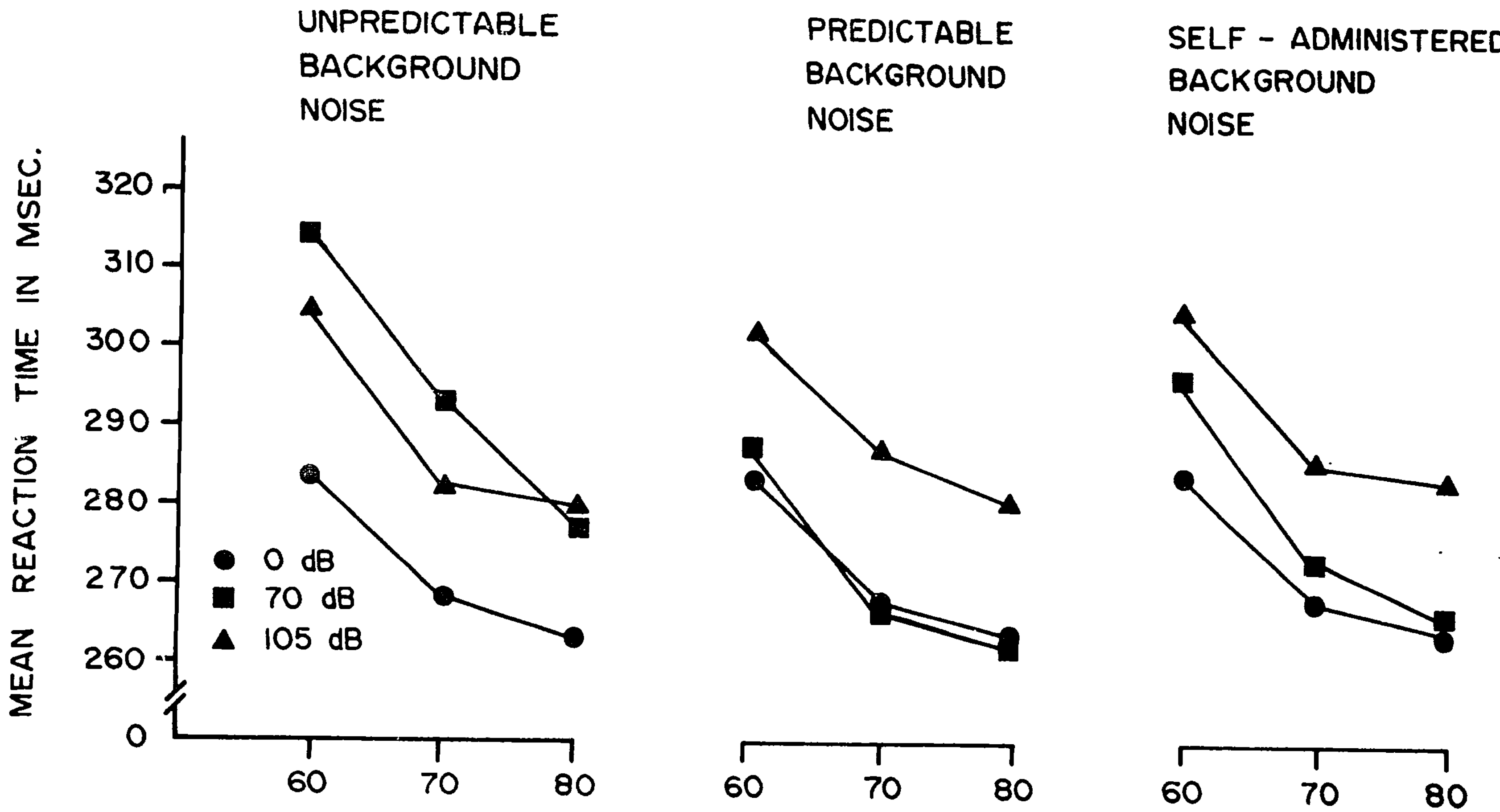
The white light stimuli are specified in decibels, re. 10^{-10} Lambert, as are the white noise stimuli, re. .0002 dyne/cm^2 for 1,000-Hz tone. Thus, the same two values in decibels of light and noise are equivalent in perceived magnitude (see Kohfeld, 1971).

The six Light and Noise Response Signals were presented randomly throughout a total of 146 RT trials per session.

A tactual ready signal was employed.

The data were analyzed according to a 4-way Analysis of Variance; two variables between -Ss, two variables within -Ss. Type of background noise (3) and *Intensity of background* noise (3) were between -S variables, and Light vs. noise (2) and Test Signal intensity were within -S variables.


SECONDS OF THE INTERTRIAL INTERVAL
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
ONE 1 – SEC. BURST
TWO 1 – SEC. BURSTS
THREE 1 – SEC. BURSTS
ONE 1 – SEC. BURST AND ONE 2 – SEC. BURST
ONE 2 – SEC. BURST
ONE 2 – SEC. BURST AND ONE 1 – SEC. BURST
ONE 3 – SEC. BURST



STIMULUS INTENSITIES IN DECIBELS COLLAPSED ACROSS WHITE LIGHT (re. 10^{-10} LAMBERT) AND WHITE NOISE (re. SPL for 1,000-Hz tone) RESPONSE SIGNALS